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## Michelle Code Usage and Validation at CPI\*

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**Abstract:** Two Michelle<sup>1</sup> models are described and results compared to practical measurements. The two models are of a gridded electron gun and a two stage depressed collector with secondary emission included.

**Keywords:** Michelle; Gridded Gun; Depressed Collector; Thermionic Correction; Secondaries

### Intercepting Gridded Gun Model

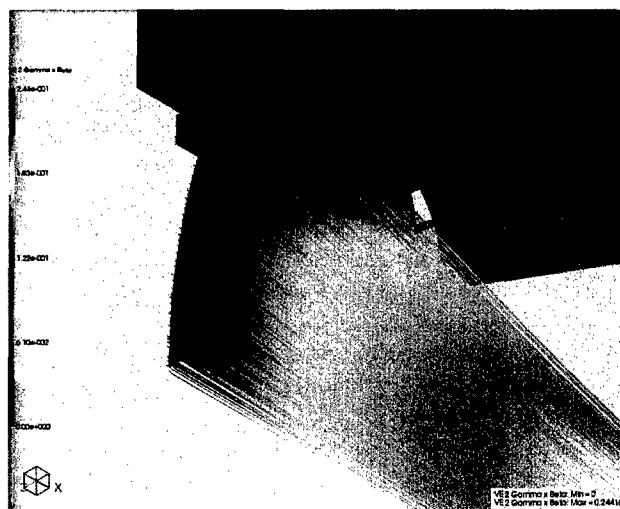
A 3D model (fig 1) of this intercepting gridded gun was initiated in 2004. The model took advantage of the symmetry of the gun geometry, a 90 degree wedge was modeled.

The gun has been in production at CPI for many years, so extensive history of performance was available, coupled with measurements of grid spacings while at operating temperature. The gun typically operates at low perveance, and has a simple square mesh grid. In preparation for the modeling, various measurements of the hot grid spacing were reviewed and appeared consistent.

Beam current for typical Egk voltages was only about 65% of measured values using the cold geometry, as might be expected. However after including the best estimates of hot geometry current only increased to 84%. Beam interception also appeared higher than measured at 18% vs 12%

Subsequently it was realized that a correction to the Childs law emission algorithm within Michelle should be used. It applies for cases where the mesh close to the cathode is very fine, as is the case for gridded guns.

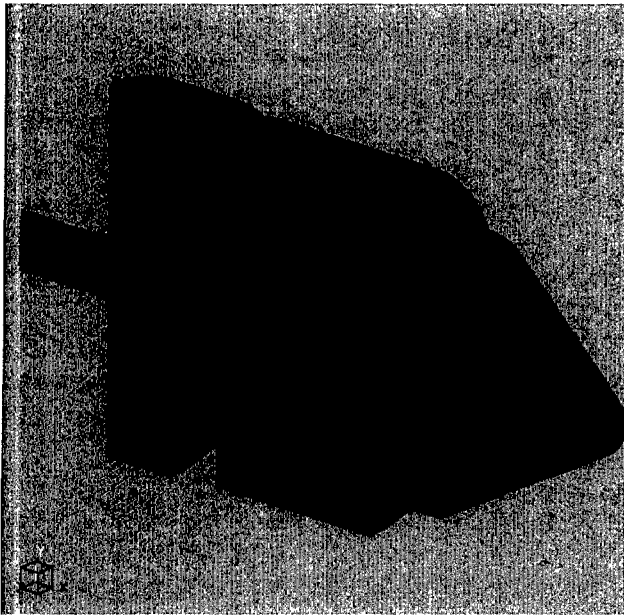
With this option selected results now give a better match to the measured values. Further refinements to this thermionic correction have been made. Predicted beam current is still low by about 8%, however it is suspected that the hot grid spacing may be smaller than prior measurements indicate.



**Fig 1 Intercepting Gridded Gun Model**

### Two stage depressed collector model

The initial Michelle model was set up in 3D. The modeling included two generations of secondary electrons, and various combinations of secondary angles and energies were investigated. This early model used a simulated DC beam with no transverse energy.



**Fig 2** 2 Stage Depressed Collector Model in 3D

Due to the large number of cells required in 3D to represent the geometry (fig 2), the number of particles used was restricted to prevent excessive run time. Results from the case did not agree well with real measurements, primarily due to the idealized primary beam that was used.

Subsequently, the model was redone in 2D axisymmetric form to take advantage of higher mesh densities, and quad meshing. This was particularly important in the beam entry region, and allowed many more particles to be used.

The simulated DC beam has also been replaced with a spent beam (no RF modulation) generated from a Christine 3D<sup>2</sup> model of the amplifier.

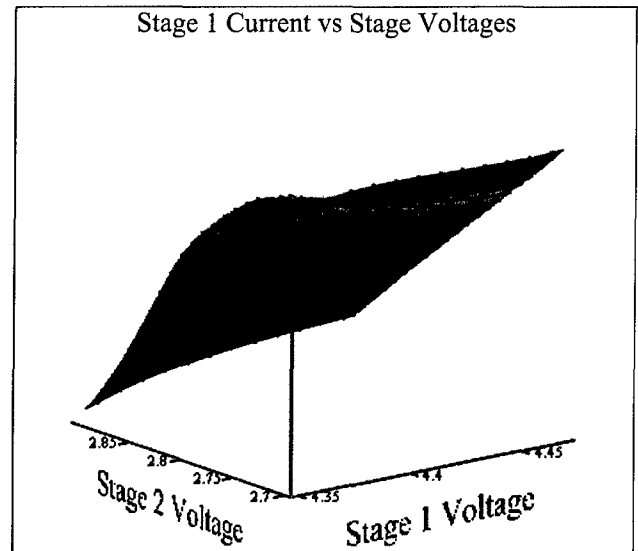
\* This work was partially supported by ONR and IR&D

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- <sup>2</sup> David Chernin, Thomas M. Antonsen, Jr., Baruch Levush, *Senior Member, IEEE*, and David R. Whaley "A Three-Dimensional Multifrequency Large Signal Model for Helix Traveling Wave Tubes", *IEEE Transactions on Electron Devices*, vol. 48, no. 1, January 2001

For comparison, practical measurements were made on the real device with an axisymmetric magnetic field. The magnetic field for the production device contains some non-axisymmetric features, which were left out to provide a valid comparison with the 2D model.

Collector stage currents and body current were measured and plotted versus stage voltages to provide a comparison with the Michelle work. The 3D surface plot (fig 3) shows one set of these measurement results, with stage 1 current depicted on the vertical axis and stage voltages on the other axes.



**Fig 3** Measured Collector Stage 1 Current